SB76.1
U8
#84-3
c.1

United States
Department of
Agriculture

Forest
Service

**Forest Pest
Management**

**Methods
Application
Group**

Fort Collins,
Colorado 80526

DEMONSTRATION OF PANORAMIC AERIAL PHOTOGRAPHY FOR MAPPING HARDWOOD DEFOLIATION OVER A MULTISTATE AREA OF THE NORTHEASTERN UNITED STATES

Report No. 84-3

3400
February 1984

DEMONSTRATION OF PANORAMIC AERIAL PHOTOGRAPHY FOR MAPPING HARDWOOD DEFOLIATION OVER A MULTISTATE AREA OF THE NORTHEASTERN UNITED STATES

by

W.M. Ciesla, R.E. Acciavatti, J.G.D. Ward, R.A. Allison and F.P. Weber[1/]
USDA Forest Service

ABSTRACT

A multistate demonstration of color-IR panoramic aerial photography for mapping hardwood defoliation by gypsy moth, Lymantria dispar L., and assessing effectiveness of suppression projects was conducted in 1983. States included in this demonstration were all or portions of Delaware, Maryland, New Jersey, and Pennsylvania. Mission planning, photo acquisition, film processing, duplication, and annotation was a cooperative effort involving three Federal agencies; the Forest Service, NASA and EPA. Photo interpretation and data transfer to a map base was done by personnel from state agencies responsible for gypsy moth pest management programs.

All aspects of this project were successfully completed. However, photo acquisition was too early for appearance of peak hardwood defoliation in the mountainous regions of the project area. This points out the need for definition of two or more biowindows over a project area of this magnitude. Cost of photo acquisition, film processing, and duplication for the 70,405 square mile project area was $1.58 per square mile.

INTRODUCTION

During 1981, an evaluation of color-IR panoramic aerial photography for mapping defoliation of hardwoods by gypsy moth, Lymantria dispar L., showed this technology to be an effective alternative to aerial sketchmapping (Ciesla and Acciavatti 1982). In addition, foliage protection in areas treated for suppression of this introduced hardwood defoliator could be assessed (Ciesla 1983). This work generated considerable interest for a large area demonstration of panoramic aerial photography for mapping defoliation over a multistate area of the northeastern United States.

[1/]The authors are respectively: Group Leader, Forest Pest Management Methods Application Group, Fort Collins, CO; Entomologist, Northeastern Area, Forest Pest Management, Morgantown, WV; Entomologist, Southern Region Doraville, GA; Remote Sensing Coordinator, Engineering, Washington, D.C.; and Director, National Forestry Applications Group, Houston, TX.

LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION

In 1983, a cooperative multistate demonstration of panoramic aerial photography involving personnel of the USDA Forest Service, NASA, EPA, Pennsylvania Bureau of Forestry, and the Pennsylvania, Maryland, Delaware, and New Jersey Departments of Agriculture was conducted. The following report describes the results of this demonstration.

METHODS

TARGET AREA

The target area comprised all or portions of four states; Delaware, Maryland, New Jersey, and Pennsylvania. All of Delaware and New Jersey were included. Planned coverage of Pennsylvania and Maryland extended west to 79° longitude. Flight plan called for 14 north-south flight lines spaced at 17 mile intervals. Two flight lines were extended into the Finger Lakes Region of western New York to provide photo coverage for a cooperative USDA/ Pennsylvania Department of Agriculture study on detection of golden nematode infestations in potatoes (Fig. 1)

PHOTOGRAPHIC PARAMETERS

Camera system used was the Itek Iris II[2/] panoramic optical bar camera. A modified version of this camera with a 90° field of view was used as opposed to the 140° field of view camera used in the 1981 evaluation (Ciesla and Acciavatti 1982). Photo platform was an ER-2 high altitude reconnaissance aircraft based at the NASA Ames Research Center, Moffett Field, California. This aircraft was deployed to Wallops Island, Virginia, for this demonstration.

Film used was Kodak High Definition Aerochrome infrared (SO-131) film. Flying height was 65,000 feet above mean sea level, providing a mean nadir photo scale of approximately 1:32,000. Biowindow for photo acquisition was timed to coincide with peak defoliation by gypsy moth which was estimated to occur within ± 10 days of July 1, 1983.

PHOTO PROCESSING

All aerial film acquired in conjunction with this demonstration was processed by the EPA, Environmental Photographic Interpretation Center (EPIC), Vint Hill Farms, Warrenton, Virginia. Original film and one duplicate copy was processed. The duplicate copy was used for photo interpretation and the original was archived at the USDA Forest Service National Forestry Applications Program (NFAP) in Houston, Texas.

PHOTO INTERPRETATION

Film was annotated by Forest Service personnel at the EPA - EPIC Laboratory, and distributed to state agencies responsible for conducting gypsy

---

2/ Mention of commercial products is for convenience only and does not imply endorsement by USDA Forest Service and its cooperators.

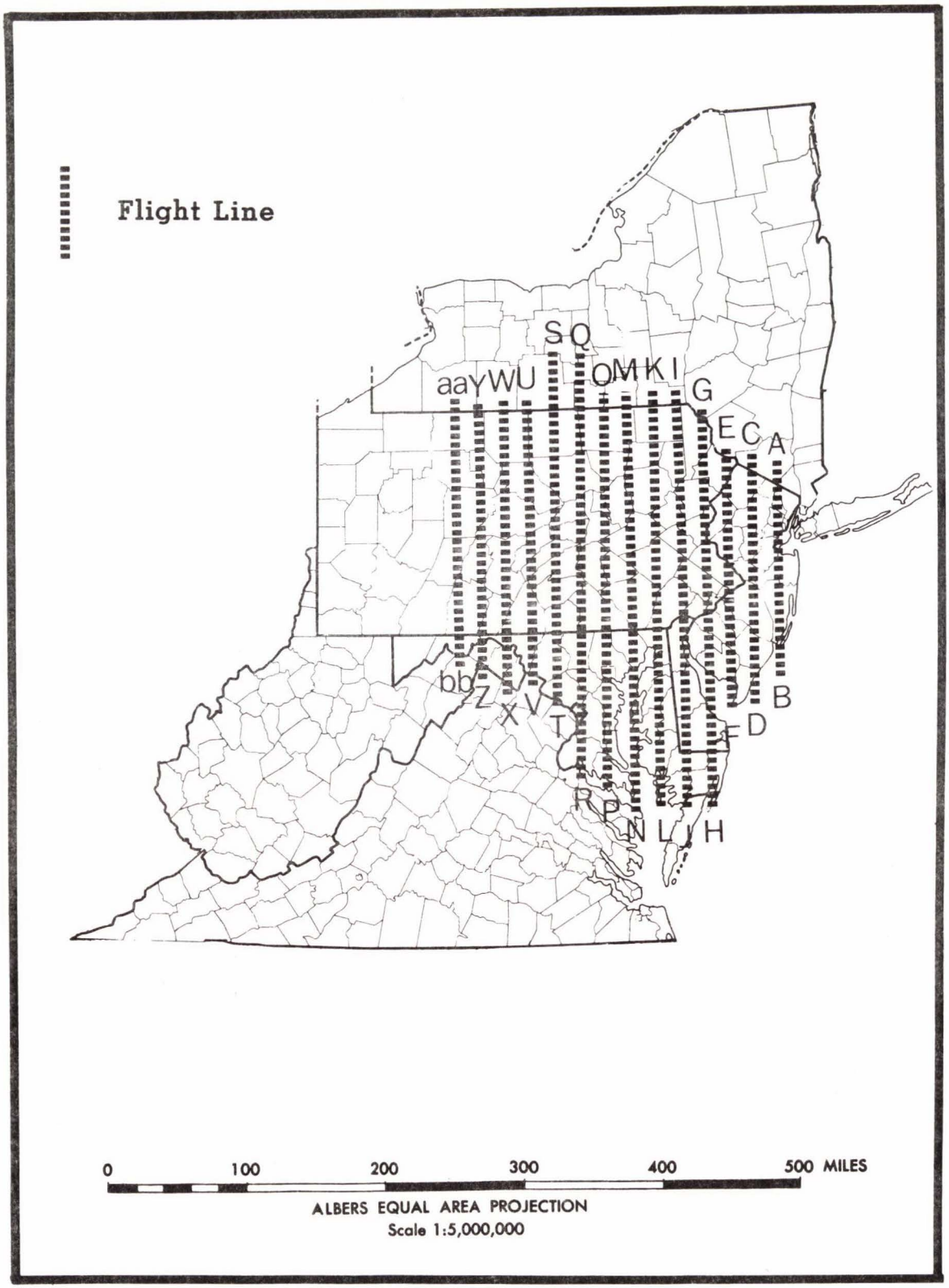

Figure 1 - Area included in the multistate demonstration of panoramic aerial photography for mapping gypsy moth defoliation in the northeastern United States - 1983. Letters at either end of flight line are flight line identifiers.

moth surveys for photo interpretation. Photo interpreters were state personnel (foresters, entomologists, or technicians) familiar with terrain features and forest cover types representative of the northeastern United States and gypsy moth defoliation.

Photo interpreters were provided formal training in the nature and properties of color-IR aerial photography, geometry of panoramic aerial photography, photo scale determination and annotation procedures, classification of hardwood defoliation, and transfer to a map base.

Interpretation procedures used were identical to those developed by Ciesla and Acciavatti (1982) and consisted of classification of hardwood forests into three damage categories:

1 - No aerially visible defoliation.

4 - Moderate and Widespread - Pure host type with first noticeable defoliation visible from aerial observation (generally 30-60% defoliation).

6 - Heavy and Widespread - Pure host type with total loss of host foliage (generally greater than 60% defoliation).

The entire photo frame (± 45° of nadir) was classified monoscopically on portable light tables. Polygons of moderate or heavy defoliation were transferred to USGS 7 1/2 minute topographic maps (scale = 1:24,000) using sketchmap techniques.

Equipment requirements were minimal and consisted of a series of portable light tables fabricated for this project by NFAP (Fig. 2), USGS 7 1/2 minute maps, and fine point felt tip markers for map transfer.

PROJECT FUNDING AND COORDINATION

Cost for photo acquisition, film, processing and duplication was estimated at $2.00 per square mile, based on a similar project; an inventory of mountain pine beetle losses in the Front Range of Colorado using panoramic aerial photography (Dillman et al. 1982). Funding for this project was made available by USDA Forest Service subject to partial reimbursement by cooperating state agencies upon successful execution of this demonstration, as follows:

Delaware Department of Agriculture	$ 2,000
Maryland Department of Agriculture	5,000
New Jersey Department of Agriculture	2,000
Pennsylvania Bureau of Forestry	20,000
Pennsylvania Department of Agriculture	10,000
	$39,000

Since the demonstration involved a number of groups within the Forest Service, and several Federal and state agencies, close coordination among cooperators was essential to insure its successful completion. A timetable of critical events was established early in the planning phase and was used to monitor progress (Table 1).

Figure 2 - Portable light table used for viewing panoramic aerial photography.

RESULTS

PHOTO ACQUISITION

The NASA aircraft arrived at Wallops Island, Virginia, on June 21, 1983. The target area was dominated by a high pressure system following passage of a cold front on June 22 and 23. This provided ideal conditions for aerial photography. Approximately 60% of the target area (western and central Pennsylvania) was flown June 22. The remaining area was flown the following day (Fig. 3).

Table 1 - Timetable of critical events, groups responsible, and actual accomplishment dates, 1983 multistate demonstration of panoramic aerial photography for mapping hardwood defoliation.

Event	Unit Responsible	Critical Date	Date Accomplished
Place order for photo mission with NASA	FS - NFAP	Jan 15	Jan 15
Advise EPA of film processing requirements	FS - Engineering	Jan 15	Jan 15
Develop training package	FS - R-8	Jan 30	Jan 30
Finalize cooperative project funding	FS - NA	Feb 15	Feb 15
Light tables delivered	FS - NFAP	Mar 15	Mar 21
Provide training to states	FS - NA & R-8	Mar 30	Mar 22-23
Photo acquisition	NASA	Jun 21-Jul 10	Jun 22-23
All film delivered to EPA	FS - Engineering	Jul 11	Jun 24
Film processing and duplication completed	EPA	Jul 15	Jun 30
Photo interpretation	States	Jul 29	Sep 15
Map products available for review	States	Aug 15	Oct 1
Post project review	FS - MAG	Oct 15	Oct 18
Final report	FS - MAG	Jan 1	Jan 30

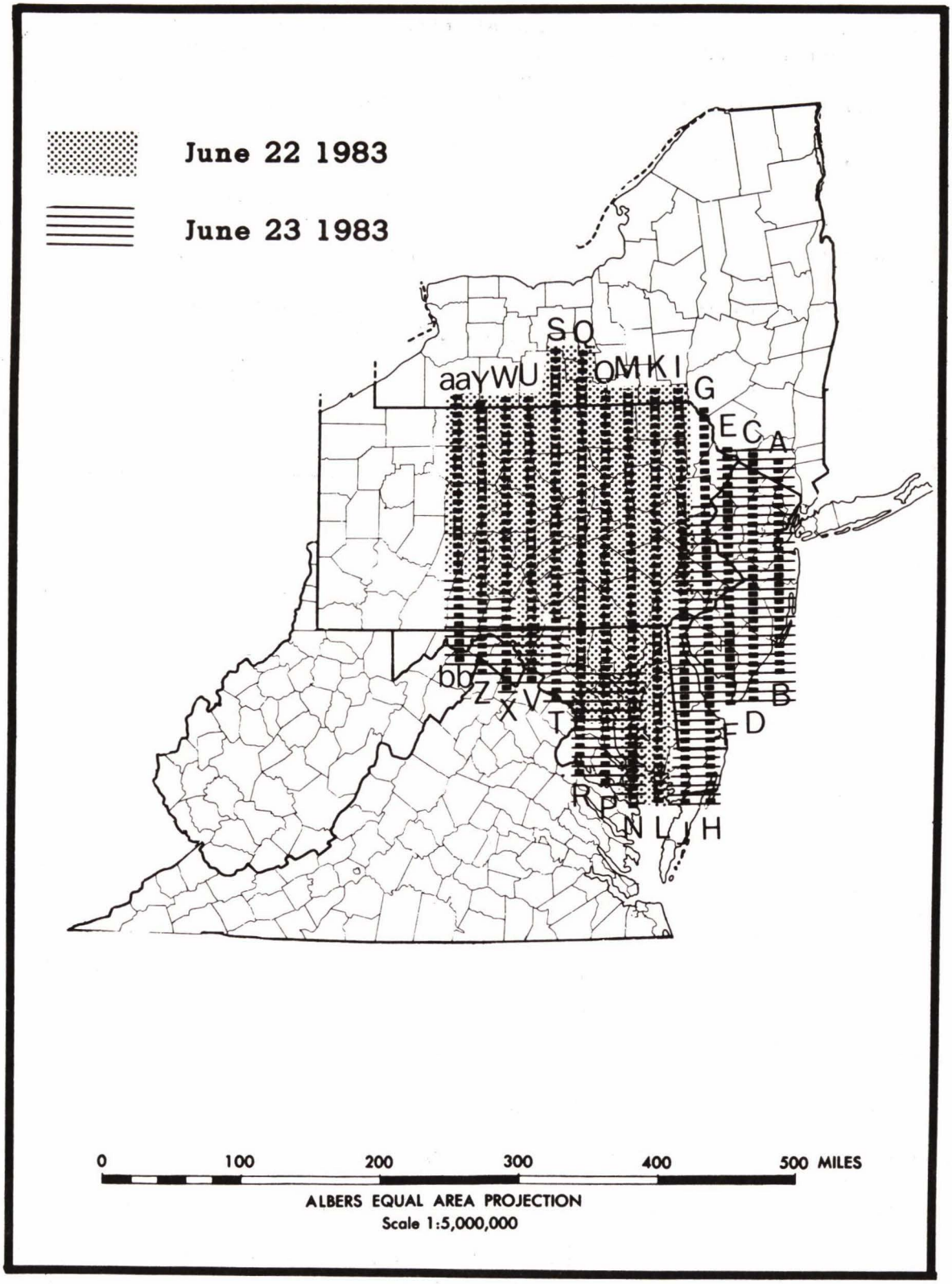

Figure 3 - Photo coverage by day, multistate demonstration of panoramic aerial photography for mapping gypsy moth defoliation in the northeastern United States - 1983.

Approximately 12,000 feet of aerial film was exposed: 2,207 frames or 7,000 feet on June 22; 1,420 frames or 5,000 feet on June 23. The camera's automatic frame counter was not activated during the first day's flight; consequently, these frames had to be later numbered manually.

PROCESSING, ANNOTATION AND DELIVERY TO STATES

Film was flown from Wallops Island, Virginia, to the EPA-EPIC lab in Warrenton, Virginia, in a chartered Cessna 172. Processing began when the film was delivered to EPA. Original film was processed by June 28, cut and placed on 600 foot spools for duplication. Duplicate copies were available by June 30. Color balance of the duplicated film was adjusted to enhance reds and maximize contrast between defoliated and undamaged areas.

Film annotation was done by marking the location of every tenth to twentieth photo frame on sectional aeronautical charts (scale = 1:500,000). In addition, flight line number, direction of flight, frame number, state and a prominent landmark appearing on each annotated frame, were recorded on a data sheet (Appendix). Airports proved to be one of the best landmarks for annotation.

When a flight line crossed a state line, film was cut and a new spool was started. A total of 28 spools of film were prepared and annotated for distribution to the states participating in this demonstration (Table 2).

Two days were required to annotate the film and separate it by state. An additional two days were required to organize notes and prepare data summaries and maps.

Table 2 - Distribution of aerial film; 1983 multistate demonstration of panoramic aerial photography for mapping hardwood defoliation.

State	Distributed to	Number of Spools
Pennsylvania	PA Bureau of Forestry	15
Southern New York	PA Department of Agriculture	1
New Jersey	NJ Department of Agriculture	4
Maryland	MD Department of Agriculture	6
Delaware	DE Department of Agriculture	1
Eastern Panhandle - West Virginia	Morgantown Field Office - USDA - Forest Service	1
Total		28

Film and photo index maps were delivered to personnel of the Pennsylvania Bureau of Forestry and Pennsylvania Department of Agriculture on July 5, and to the Delaware and Maryland Departments of Agriculture on July 7. Film was delivered to the New Jersey Department of Agriculture on July 12.

PHOTO QUALITY

Overall photo quality was judged to be excellent. Color balance of the duplicated film was optimum for classification of defoliation. Cloud cover was minimal and consisted of scattered cumulus clouds on only a few photo frames.

All photo coverage requested was obtained except for a portion of northeastern Pennsylvania; Stroudsburg to the New York state line. This area is believed to have been obscured by cloud cover on June 22. Three short gaps between flight lines where no photo coverage was obtained occurred in Pennsylvania. In addition to the planned coverage, portions of the eastern Panhandle of West Virginia and adjoining portions of Virginia and all of Manhattan and Staten Island, New York, were included.

At the time of photo acquisition, gypsy moth defoliation was nearly at its peak in central and southern New Jersey, Delaware and Maryland. Insect development was considerably later in the mountainous regions of northern New Jersey and central and northern Pennsylvania due to increased elevation and an unusually cool, wet spring. There were serious initial concerns that the flight was made 7 to 10 days too early. Preliminary viewing of the film, however, revealed extensive areas of hardwood defoliation in the mountainous regions of western Maryland and southern Pennsylvania. In Pennsylvania, defoliation could be readily discerned as far north as Altoona. From this point north defoliation gradually became more faint (Fig. 4).

PHOTO INTERPRETATION[3/]

DELAWARE - In Delaware gypsy moth defoliation peaked about one week earlier than the photo mission flight date. Defoliation in the two previous years had peaked around the third week of June; however, the 1983 mission dates did not pose any photo interpretation problems.

After delivery of the film, one half day was spent in orientation and regaining familiarity with the photography. Photo interpretation required two person days. The time spent in photo interpretation includes map transfer to the USGS quad sheets and acreage determination with the use of a digital planimeter. Defoliation was mapped in the standard moderate and heavy categories. For in-state use, defoliation was summarized by county.

3/ This section is assembled from reports provided by Kevin C. Donnelly, Delaware Department of Agriculture; Benedict B. Pagac, Jr., Maryland Department of Agriculture; Thomas Denholm, New Jersey Department of Agriculture; and John Quimby, Pennsylvania Bureau of Forestry, and presented at the National Gypsy Moth Annual Review, Albany, New York, December 6-8, 1983.

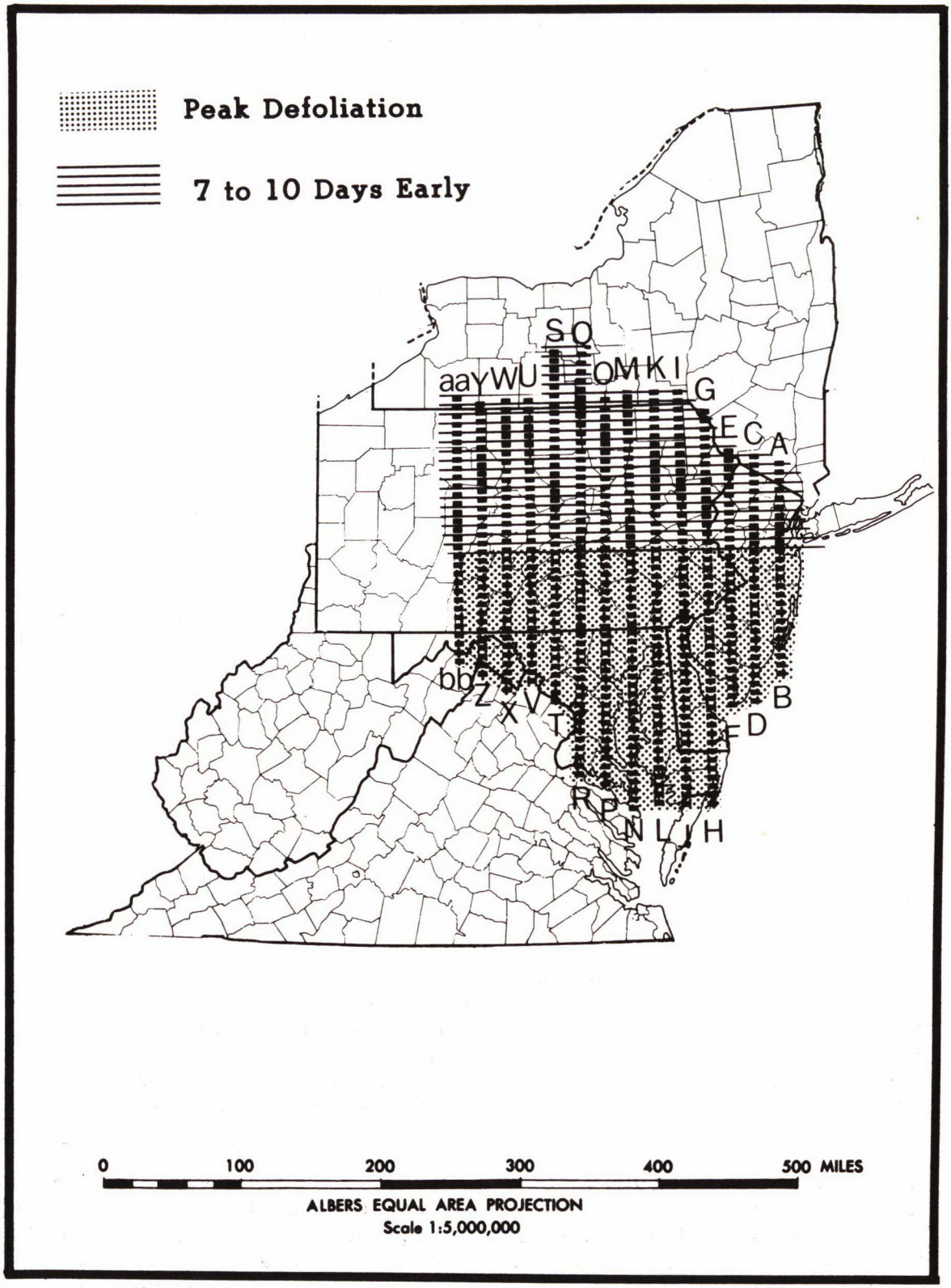

Figure 4 - Status of gypsy moth development and resultant defoliation over multistate demonstration area during June 22-23 photo acquisition period.

The Delaware Forest Service sees three primary uses for the panoramic photography. The first, and most important, is for mapping defoliation. It is an excellent mapping and tracking tool in the gypsy moth suppression program. In 1983 all newly defoliated areas were ground checked and no instances of interpretation error were found. We will continue to ground check newly defoliated areas in the future. Of particular concern will be the behaviour of the gypsy moth in the oak-loblolly pine type. The current egg mass survey has not detected any infested stands in this forest type. When this occurs it may be necessary to specify earlier windows to map peak defoliation in the southern part of Delaware.

The second use of the photography in Delaware was as a planning tool. The 1983 photography was used to direct the location and intensity of egg mass surveys. It is also useful in the preparation of gypsy moth suppression budgets and, in combination with stand type and egg mass survey data, it is being used to predict 1984 defoliation.

The third use for the 1983 photography was as a public information and education tool. A press release announcing the participation of the Delaware Forest Service in the 1983 photo mission generated two newspaper articles and one taped television interview. This positive coverage can benefit states beginning to formulate gypsy moth suppression programs. We used the photography in conjunction with a legislative tour of our State Forest spray blocks. The photography was also available for the legislators to view defoliation in their districts. We plan to use the photography in a meeting in January in which the results of the egg mass survey will be presented.

Future use of this photography depends on the interest the Delaware Department of Agriculture can generate among other state, municipal, and private land managers. Interest in this photography has been shown by Cooperative Extension for use in their agricultural pest management programs. The Delaware Department of Agriculture's Ag Lands Preservation and Noxious Weed Sections are investigating its value in their programs. In the future the Delaware Forest Service plans to use panoramic photography to assess forest tent caterpillar, Malacosoma disstria Hbn., damage and moniter southern pine beetle, Dendroctonus frontalis Zimm., outbreaks.

MARYLAND - The entire state of Maryland was photographed except for western Allegany County. It required 10 person days to interpret six spools of film containing 752 frames. Although conventional systematic aerial sketchmapping was not used this year, field personnel flew 11.2 hours in a Cessna 172 between June 27 and July 5 in order to evaluate suppression program treatment areas, thus providing an opportunity to corraborate many photo interpretation findings.

Statewide gypsy moth defoliation totaled 15,870 acres and was found in eight counties. Heavy defoliation totaled 4,308 acres; moderate defoliation totaled 11,562 acres. The timing of the flight, a critical factor, appeared to coincide with the overall peak defoliation period in Maryland, although there were some defoliated areas in the higher elevations of western Maryland which showed a slightly greater degree of defoliation four to six days after the flight.

Determining the amount of defoliation occurring within treatment areas is one measure of suppression project effectiveness. Based upon photo interpretation, there were 1,997 acres of hardwoods defoliated (at a $\geq$30% level) within 1983 suppression spray blocks. Considering that 120,082 acres were treated statewide, the suppression program appears to have been 98.3% effective in foliage protection at a 30% or greater defoliation level. This information, along with the analysis of patterns of defoliated areas within or adjacent to spray blocks, provided additional insight into the performance of spray materials, applicators, and aircraft.

Panoramic aerial photography proved valuable for mapping gypsy moth defoliation in Maryland. There are indications that other state agencies could benefit from use of this film. Interest has already been shown by organizations such as the Maryland State Department of Planning, Maryland Geological Survey, and Baltimore City Water Quality Management Office.

NEW JERSEY - One photo interpreter worked with the New Jersey photo coverage. Thirteen days of photo interpretation time were required to map defoliation. Between 13 and 20 frames were completed per day. This varied with the amount of defoliated area which appeared in the frame. In addition, photo interpretation rate increased as the photo interpreter became more experienced.

Mission timing was optimum for the southern two-thirds of the state. Of the remaining area, location of infestations in northwestern New Jersey could be mapped fairly well; however estimates of severity were conservative. In the northeastern portion of the state, where only moderate defoliation occurred in 1983, neither location nor severity could be accurately mapped.

The photography was effective for assessing spray treatments. It is being used to evaluate application quality, location of missed areas, long runs, late turn ons, and spraying beyond block boundaries.

In addition to gypsy moth related uses, the photography is being used to locate red pine stands which will be examined on the ground later for red pine scale, Matsucoccus resinosae Bean and Godwin. It has not been used for mapping tree mortality to date because it is felt that additional interpreter experience and ground data is necessary. The photography is also being evaluated by the New Jersey Department of Environmental Protection for mapping riparian areas.

PENNSYLVANIA - Initially 10 people with the Pennsylvania Bureau of Forestry were assigned to participate in the photo interpretation of hardwood defoliation. However, when it became apparent that the northern two-thirds of the state was flown too early, it was necessary to reassign some members of this team to conduct a supplemental aerial sketchmap survey.

Seven photo interpreters spent varying amounts of time classifying defoliation and transferring this information to maps. Total time was 49 person days, with each interpreter completing an average of 8 frames per day. This ranged from 20-25 frames per day in areas of little or no defoliation to 3-4 frames per day where extensive areas were defoliated and the terrain was

complex. Additional time was spent with the photography to map tree mortality, evaluate effectiveness of aerial sprays and to classify timber types.

The photography was satisfactory for locating and delineating areas defoliated by gypsy moth in that portion of Pennsylvania south of latitude 40°30' (Altoona/Newport). Defoliation could not be discerned north of that line. Photos were of considerable benefit in evaluating foliage protection in spray blocks and for evaluating such factors as swath width, application quality by different types of aircraft, and efficacy of various spray materials. This use has the potential to be of major utility for forest pest managers.

In addition, the photography was useful to confirm defoliation in areas where the resource is especially valuable, such as prime timber producing sites, historical sites, and park lands. Under these conditions, the photos will be especially useful in future years to document presence of defoliation in areas that may otherwise have unexplained tree stress or mortality.

Groups of tree mortality could be readily identified in areas where no current defoliation was present. However, where both mortality and defoliation occurred, they were difficult to separate. One State Forest Management District instituted an accelerated timber salvage program in 1983. They made use of the optical bar photography to map areas of mortality in advance of the initial cruising of the proposed salvage sales.

Some problems encountered by photo interpreters included:

1. Defoliated areas were not readily discernible from areas of extensive tree mortality or frost injury. In addition, certain tree species, especially eastern white pine, Pinus strobus L., have signatures similar to defoliated hardwoods on the color-IR film; when those occurred in pure stands, misclassification occurred. Additional ground data and photo interpreter experience might help separate these conditions.

2. Inexperienced photo interpreters found the job tedious. In some cases there was a tendency to "overinterpret" and spend too much time on a single frame. Resolution and photo quality is almost too detailed for a defoliation survey.

In addition to gypsy moth related activities, the Pennsylvania Department of Agriculture, Bureau of Plant Industry used this photography for a wide range of applications. These included:

1. Determine area planted to potatoes; including computation of expected statewide harvest, disease detection, size of fields, and an attempt to identify cultivars through digitization.

2. Determine intensity and location of the state's potato crop. Is the potato crop aggregated or evenly distributed in a county? This will help with ground surveys.

3. Determine land use in vicinity of farms affected by avian flu; proximity of pollution sources, other infected hen houses. Identify high risk areas. Also, the distribution of laying houses was mapped.

4. Inventory of Christmas tree plantations.

5. Follow progression of crops. Are field crops being rotated? This is especially important in corn as the corn cyst nematode takes five years to reach epidemic levels.

6. Locate fields planted to peas to narrow down the search for the pea cyst nematode. Pea fields are isolated through a process of elimination of other crops that are more easily identified. Grains, corn, and potatoes are relatively easy to detect, eventually the signature for peas was recognized.

7. A preliminary nursery survey. Priority for on-the-ground inspections was established based on data obtained from photos.

PROJECT COSTS

Cost of photo acquisition (aircraft time plus film) was $86,500. Film processing and duplication was $25,000 which included only the cost of materials. Labor and laboratory facilities associated with processing and duplication were contributed by EPA. Approximately 70,405 square miles of the earth's surface were covered by the project at a per unit acquisition cost of $1.58 per square mile. This is somewhat less than the $2.00 per square mile anticipated cost. Lower than anticipated per unit cost is due to additional land area covered by the photo mission.

DISCUSSION AND CONCLUSIONS

This demonstration achieved its objectives in that all critical targets in the planning timetable were met. High altitude panoramic aerial photography is a viable alternative to aerial sketchmapping for mapping hardwood defoliation in an operational environment. A joint Forest Service/State effort, under the leadership of the Northeastern Area, should continue and be expanded to include other states affected by gypsy moth infestations.

The major problem encountered was the delayed insect development in the mountainous regions in the northern and western portions of the target area, due to the unusually cool, wet spring of 1983. The next period of suitable weather for aerial photography occurred over the target area on July 7 and 8. This time period would have been more suitable for the mountainous regions; however, ground examinations on July 7 of areas which imaged as heavy defoliation in central Delaware had already begun to refoliate. Had the photo mission been delayed until this second period, these areas would not have been as readily discerned because of refoliation, and data would have been lost.

The wide range of gypsy moth development times and periods of peak defoliation over the target area points out the need for definition of two or more photo acquisition biowindows when planning and conducting expanded operational surveys of panoramic aerial photography for mapping hardwood defoliation and assessing effectiveness of gypsy moth suppression projects. This need will become more apparent as the insect continues to expand its range southward and westward into regions of warmer climate as well as a greater change in elevation.

A second problem encountered was the presence of commission error; photo interpreters mistaking areas of late spring frost, tree mortality, or pre-stands of certain conifers, for hardwood defoliation. This source of error will undoubtedly be minimized as forest pest management specialists in the Northeast gain more experience with the appearance of forest vegetation and damage on color-IR film. This experience will best be gained through a combination of photo interpretation and ground checking of questionable areas.

ACKNOWLEDGMENTS

The authors extend their thanks to the personnel of the U-2 Support Group, NASA Ames Research Center, Moffett Field, California, and the EPA, Environmental Photographic Interpretation Center, Warrenton, Virginia, for their assistance and support without which this demonstration could not have been successfully completed. Daniel R. Kucera and Robert E. Wolfe, USDA Forest Service, Northeastern Area, Broomall, Pennsylvania, provided a constructive review of the manuscript.

REFERENCES CITED

Ciesla, W.M. and R.E. Acciavatti. 1982. Panoramic aerial photography for mapping gypsy moth defoliation. USDA Forest Service, Forest Pest Management, Methods Application Group, Fort Collins, CO. Rpt. 83-1, 17 pp.

Ciesla, W.M. 1983. Panoramic aerial photography for assessing foliage protection achieved by aerial sprays directed against the gypsy moth. USDA Forest Service, Forest Pest Management, Methods Application Group, Fort Collins, CO. Rpt. 83-4, 14 pp.

Dillman, R.D., S.S. Shen, B.B. Eav and W.B. White. 1981. Operational test of panoramic aerial photography for estimating annual mortality of ponderosa pine caused by mountain pine beetle. Lockheed Engineering and Management Service Company, Inc. Houston, TX. Rpt. No. LEMSCO - 16377, 20 pp.

APPENDIX

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 22, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
AA-BB	1	PA	Johnstown Airport
(S to N)	13	PA	Edensburg
	27	PA	Barnesboro
	49	PA	Punxsutawney
	66	PA	DuBois Airport
	81	PA	Portland Mills
	96	PA	Russell City
	104	PA	Kane
	117	PA	Warren
	122	PA	NY/PA State Line
	135	NY	End of Flight Line
Y-Z	136	NY	Begin Flight Line
(N to S)	142	PA	Bradford
	153	PA	Smethport
	171	PA	East Br. Reservoir
	175	PA	Rolfe
	215	PA	Clearfield
	239	PA	Glendole L.
	253	PA	Altoona
	279	PA	Osterburg
	286	PA	Bedford Airport
W-X	289	PA	Breezewoood
(S to N)	307	PA	Saxton
	343	PA	Tyrone
	352	PA	Sandy Ridge
	393	PA	Driftwood
	405	PA	Emporium
	425	PA	Port Alleghany
	445	NY	Portville
	449	NY	Olean
	452	NY	End of Flight Line
U-V	453	NY	Wellsville
(N to S)	459	NY	Whitesville
	511	PA	Renova
	528	PA	Orivston
	534	PA	Snowshoe
	547	PA	Bellefonte Airport
	582	PA	Mt. Union
	605	PA	Littleton
	616	PA	McConnellsburg
	627	PA	Greencastle
	645	MD	Williamsport
	644	MD	End of Flight Line

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 22, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
S-T	645	PA	Monterey
(S to N)	670	PA	Shippensburg
	679	PA	Newburg
	707	PA	Port Royal
	710	PA	Lewistown
	728	PA	Snyder-Middleswarth
	752	PA	Lock Haven
	819	NY	State Line
	826	NY	Howard
	844	NY	Bath
	848	NY	Osceola
	856	NY	Cohocton
	865	NY	Naples
	869	NY	Canandagua
Q-R	870	NY	Penn Yan
(N to S)	880	NY	Pelteney
	907	NY	Corning
	918	PA	State Line
	926	PA	Tioga
	932	PA	Mansfield
	974	PA	Williamsport
	999	PA	Mifflinburg
	1050	PA	Carlisle
	1057	PA	Dillsburg
	1077	PA	Gettysburg
	1085	PA	Littlestown
	1097	MD	Westminister
	1130	MD	Gaithersburg
	1148	DC	Washington, D.C.
	1152	DC	Washington National Airport
	1164	DC	End Flight Line
O-P	1165	MD	Patuxent River
(S to N)	1201	MD	Baltimore Airport
	1232	MD	Monkton
	1242	MD	Maryland Line
	1275	PA	Three Mile Island
	1278	PA	Harrisburg
	1331	PA	Sunbury
	1356	PA	Munsy
	1400	PA	Troy

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 22, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
M-N	1429	PA	North Orwell
(N to S)	1440	PA	Towanda
	1493	PA	Berwick
	1521	PA	Pottsville
	1546	PA	Meyerstown
	1569	PA	Landcaster
	1594	MD	State Line
	1611	MD	Aberdeen
	1653	MD	Annapolis
	1685	MD	Taylors Island
	1699	MD	Lexington Park Airport
	1717	MD	Point Lookout
K-L	1725	MD	Crisfield
(S to N)	1746	MD	Nanticoke
	1763	MD	Vienna
	1841	MD	Aberdeen Airport
	1848	MD	Havre de Grace
	1862	PA	State Line
	1866	PA	Oxford
	1879	PA	Christiana
	1911	PA	Reading Airport
	1937	PA	New Ringold
	1957	PA	Hazelton Airport
	2001	PA	Tunkhannock
	2023	PA	Montrose
	2043	NY	Binghamton
I-J	2044	NY	Windsor
(S to N)	2053	PA	Oakland
	2098	PA	Scranton Airport
	2150	PA	Allentown Airport
	2180	PA	Pottstown
	2203	PA	Westchester
	2207	PA	End of Mission

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 23, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
A-B	1	NJ	Beach Haven
(S to N)	11	NJ	Barnegat Light
	25	NJ	Seaside Heights
	35	NJ	Beston Woods
	45	NJ	Monmouth County Airport
	57	NJ	Rumson
	65	NJ	Keenesburg
	75	NY	Staten Island
	85	NJ	Newark Airport
	113	NY	Suffern
	133	NY	Harriman
	147	NY	Newberg Airport
C-D	157	NY	Port Jervis
(N to S)	169	NJ	Sussex
	176	NJ	Ogdensburg
	191	NJ	Dover
	199	NJ	Hanover
	215	NJ	Sommerville
	234	NJ	Princeton
	247	NJ	Trenton
	293	NJ	New Gretna
	301	NJ	Pomona Airport
	307	NJ	Pleasantville
	317	NJ	Ocean City
E-F	323	NJ	Cape May
(S to N)	327	NJ	Wildwood Airport
	345	NJ	Woodbine
	355	NJ	Millville Airport
	368	NJ	Vineland
	402	NJ	Camden
	412	PA	Pennsylvania State Line
	414	NJ	New Jersey State Line
	415	NJ	Levitown Airport
	427	NJ	Trenton Airport
	445	NJ	Teterboro
	457	NJ	Spruce Run Reservoir
	473	NJ	Hackettstown
	497	NJ	Delaware R.

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 23, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
G-H	498	PA	Tannersville Airport
(N to S)	504	PA	Stroudsburg
	515	PA	Belvidere
	543	PA	Lake Noxamixon
	563	PA	Willow Grove Airport
	587	PA	Philadelphia Airport
	590	NJ	State Line
	592	NJ	Bridgeport
	621	NJ	Bridgeton
	638	NJ	Egg Island Point
	668	DE	Cape Henlopen/Lewes
	692	DE	Selbyville
	694	MD	Bishopville
	704	MD	Berlin Airport
	730	VA	Chincoteague
	738	VA	End of Flight Line
I-J	743	VA	Chincoteague Airport
(S to N)	753	MD	Pocomoke
	777	MD	Salisbury
	783	MD	Delmar
	798	DE	Seaford
	835	DE	Dover
	868	DE	Delaware City
	879	DE	New Castle
	889	DE	Wilmington
	890	PA	Chester
	896	PA	Westchester
	901	PA	Westchester
	911	PA	Phoenixville
O-P	914	MD	Baltimore
(N to S)	919	MD	Baltimore Airport
	926	MD	Ft. Meade
	973	MD	Hughesville
	990	MD	Colton
	997	VA	Coles Point
Q-R	1000	VA	Begin Flight Line
(S to N)	1008	VA	Colonial Beach
	1018	MD	Newburg
	1031	MD	LaPlata
	1051	DC	South Washington, D.C.
	1052	DC	End Flight Line

ANNOTATION NOTES FOR AERIAL PHOTOGRAPHS

MISSION OF JUNE 23, 1983

Flight Line & Direction	Frame No.	State	Prominent Landmark
S-T	1079	MD	Frederick
(S to N)	1095	MD	Thurmont
	1103	MD	Emmetsburg
	1107	PA	End of Flight Line
U-V	1117	PA	Cove Gap
(N to S)	1130	MD	Maryland State Line
	1132	MD	Hagerstown
W-X	1218	WV	Berkeley Springs
(S to N)	1223	MD	Hancock
	1225	PA	State Line
	1246	PA	Breezewood
	1259	PA	Hopewell
	1265	PA	Saxton
	1267	PA	End of Flight Line
Y-Z	1268	PA	Osterburg
(N to S)	1278	PA	Bedford
	1285	PA	Burning Bush
	1301	MD	State Line
	1315	WV	Paw Paw
AA-BB	1353	MD	Cumberland
(S to N)	1357	PA	State Line
	1366	PA	Hyndman
	1374	PA	Berlin
	1381	PA	Indian Lake
	1391	PA	Hooverville
	1398	PA	Windburg
	1404	PA	Johnstown Airport
	1418	PA	Edensburg
	1420	PA	End of Flight Line